I multiplied by 10,000 to get easy numbers. The insolation loss always kept below 1 per cent, except at quite low solar altitude, and was generally negligible. I always made three measurements, of which the mean was taken. At constant sun their variations keep within narrow limits; they mostly amount to about 1 per cent of the mean value. Sudden jumpings like those occurring with the zinc ball photometer were not seen. The time of discharge was regulated by different large diaphragms, and nearly always varied between the limits of 12 and 25 seconds.

The method is especially fit to be used in fixing the ultra violet local clearness by switching in several mat quartz plates. The diminution of radiation, which ensues, is fatal to the galvanometric method, but in this case it is generally desirable. Further, this method has been applied to the comparison of the intensity of the quartz lamp (so much used in medicine now) and that of the sun within that ultra-violet spectrum section, which both kinds of radiation have in common. Ten different burners partly new, partly old ones were examined. The exact data were published in "Strahlentherapie," Band XIV, Heft 1 (Urban & Schwarzenberg, Berlin). The result, which will interest most here, is: The Hanauer quartz lamp, supplied with a new burner (so called *Künstliche Höhensonne*) furnishes:

At 100 cm. distance..	3.7 fold	sun intensity, in relation to Davos sun intensity at the mean of sun's altitude.
At 70 cm. distance..	6.1 fold	
At 50 cm. distance..	12.2 fold	

Some simultaneous comparison measurements, made in Chur (587 m.), Davos (1,590 m.), Schatzalp (1,860 m.), furnished the result that within these altitudes with a cloudless sky observation and calculation from transmission coefficient (the different sea levels being taken into consideration) are in good agreement, except during special weather conditions. For instance, when there is a foehn prevailing, decending far into the valley of the Rhine, while it passes above the Davos valley, then there arise above the latter light strata, recognized by the whitish blue color of the sky, in the former. However, the air is then of the highest possible transmissibility—in this case the Chur values have been considerably higher than those resulting from calculation.

INFLUENCE OF COVER CROPS ON ORCHARD TEMPERATURES.

By FLOYD D. YOUNG, Meteorologist.

[Weather Bureau Office, Los Angeles, Calif., October 1, 1922.]

Among the growers of citrus fruits in California the belief that the presence of a cover crop in a citrus grove greatly increases the frost hazard has been growing rapidly during the past few years. Several reputable citrus growers have found much more damaged fruit in portions of their groves in cover crop than in clean cultivated sections. Other growers have stated that cover crops lowered the temperature of their orchards as much as 8° during frosty nights. As a result of this belief the tendency in orchard management has been away from winter cover crops.

Cover crops are considered by agricultural specialists to be of unquestioned value in maintaining the fertility of the soil and supplying humus. In some sections of California cover crops in citrus groves are considered to be absolutely necessary on account of soil conditions. Much additional irrigation water is required to grow summer cover crops in citrus groves, and where water is scarce summer cover crops are out of the question. Unless plenty of water is available for both cover crop and trees the cover crop will compete with the trees for moisture, with resulting injury to the tree. During most winter seasons in California there is abundant rainfall and winter cover crops can be grown without irrigation.

Early in the fall of 1921 the Weather Bureau was requested by officials of the Citrus Experiment Station at Riverside, Calif., to carry out experiments to determine to what extent, if any, a cover crop lowered the temperature on a frosty night.

A number of investigators had already studied this question by the simple expedient of selecting two groves, side by side, one in cover crop and the other clean cultivation, and making temperature observations in the two on frosty nights. Several years work in investigating frost conditions in southern California had demonstrated that such methods would be open to criticism. Differences in temperature of several degrees are often found within a few hundred feet on frosty nights, on ground which to the eye appears perfectly level. This being the case, differences in temperature observed between adjoining groves may be due entirely to causes other than the presence or absence of cover crops.

The plan of operation decided upon was as follows: It was desired to obtain a 10-acre orange or lemon grove in which the cover crop had attained considerable growth early in the fall, and divide it into two 5-acre sections. Temperature stations were to be installed at about the center of these 5-acre plots, the stations to be moved about until two points were found where the temperatures were as nearly the same as possible. After it had been demonstrated that there was a consistent relation between the temperatures at the two stations, the cover crop in one of the 5-acre plots was to be plowed under, and the ground cultivated thoroughly.

It was necessary to find a grove in cover crop which was surrounded by clean cultivation for some distance on every side, or to plow up a very large section of a grove in a neighborhood where all the groves were in cover crop. This is due to the fact that if the cover crop did depress the temperature to any great extent, this cooling effect would be felt some distance away over a clean cultivated area, due to the air drift which is practically always found in this section on a frosty night.

Much difficulty was experienced in finding a suitable grove, the owner of which was willing to plow under half his cover crop about two months earlier than usual. This was to be expected, since no money was available with which to make up the grower's loss. It finally was necessary to accept the offer of a 6-acre orange grove, near Pomona, Calif., belonging to Mr. H. J. Nichols. Mr. Nichols deserve much credit for his cooperation in this work, which was carried on for the benefit of all the citrus growers in the State.

DESCRIPTION OF THE GROVE.

The grove selected lies on practically level ground. Navel orange trees, 25 years old, are set 20 feet apart, shading a consiserable portion of the ground. The soil is a sandy loam, very deep, and without gravel. The cover crop consisted of *Melilotus indica* sowed 30 pounds to the acre, and rye, 10 pounds to the acre, with a scattering of purple vetch. Toward the end of the frost season the rye stood 2½ feet high, with a heavy crop of *melilotus* extending to a height of about 6 inches above the ground. (See figs. 1 and 2.) The grove was entirely surrounded by clean cultivated ground.

In spite of the fact that the ground was practically level, and the stations were only about 200 feet apart, it was necessary to shift the positions of the instrument shelters several times before the lowest temperatures on frosty nights at the two stations agreed within one-half degree.

EXPOSURE OF INSTRUMENTS.

Stations were finally located in the interior of the grove, one near the northern end and the other near the southern end. The instrumental equipment and exposure of instruments was the same at both stations. Fruit-region instrument shelters, containing minimum thermometers and 29-hour thermographs, were installed on supports at both stations, so that the thermometers were 5 feet above the ground. Fruit-region shelters, containing the same instrumental equipment, were set directly on the ground at both stations, the thermometers being 10 inches above the ground.

The two stations were designated "North" and "South" for the purpose of identifying them.

After the permanent locations for the stations had been selected, eight clear, frosty nights were allowed to pass, in order to establish a definite temperature relation between the two stations. Minimum temperatures registered on these nights are shown in Table 1. Minimum temperatures averaged 0.6° F. lower at the south station than at the north station during this period, both at the 5-foot elevation and in the shelter on the ground.

TABLE 1.—*Minimum temperatures, °F., on frosty nights (sheltered thermometers).*

[Entire grove still in cover crop.]

Date.	5-foot elevation.			10-inch elevation.		
	North plot.	South plot.	Difference.	North plot.	South plot.	Difference.
Jan. 6	31.3	30.5	−0.8	30.7	30.1	−0.6
9	30.4	30.1	−0.3	31.0	30.4	−0.6
11	35.2	34.4	−0.8	34.1	33.6	−0.5
12	32.1	31.9	−0.2	31.3	30.4	−0.9
13	29.0	28.2	−0.8	28.0	27.6	−0.4
14	31.3	31.4	+0.1	30.1	29.1	−1.0
15	31.5	30.6	−0.9	30.5	30.0	−0.5
16	31.0	30.0	−1.0	30.1	29.8	−0.3
Average	31.5	30.9	−0.6	30.7	30.1	−0.6

TABLE 2.—*Minimum temperatures, °F., on frosty nights (sheltered thermometers).*

[North plot clean cultivation; south plot in cover crop.]

Date.	5-foot elevation.			10-inch elevation.		
	North plot.	South plot.	Difference.	North plot.	South plot.	Difference.
Jan. 20	19.8	20.0	+0.2	19.4	20.0	+0.6
21	22.0	21.3	−0.7	22.4	21.0	−1.4
22	24.6	23.4	−1.2	24.0	22.7	−1.3
23	25.2	24.0	−1.2	25.0	23.1	−1.9
24	28.0	27.0	−1.0	27.5	25.0	−2.5
25	30.8	29.9	−0.9	30.0	27.0	−3.0
26	28.5	28.1	−0.4	28.0	27.0	−1.0
27	28.4	28.1	−0.3	28.2	27.1	−1.1
Feb. 1	28.1	27.8	−0.3	29.5	27.7	−1.8
2	28.4	27.2	−1.2	29.0	27.0	−2.0
3	25.1	24.3	−0.8	26.1	24.0	−2.1
4	27.0	26.0	−1.0	27.4	26.0	−1.4
5	28.1	27.6	−0.5	29.0	27.3	−1.7
6	32.4	31.7	−0.7	32.3	30.3	−2.0
Average	26.9	26.2	−0.7	27.0	25.4	−1.6

NORTH PLOT COVER CROP PLOWED UNDER.

On January 18, 1922, the cover crop in the north plot was plowed under, but the south plot was not disturbed. If the cover crop had been exerting a marked influence on the temperature, the temperature in the north plot (now clean cultivation) should now be considerably higher than that in the south plot, still in cover crop.

After January 18, when the cover crop was plowed under, temperature records were obtained covering 16 frosty nights, including the exceptionally cold period from January 19 to 23, the coldest weather that has been experienced in southern California since 1913. Minimum temperatures recorded at the two elevations in both plots each night during this time are shown in Table 2.

It will be seen that the average difference in minimum temperature between the two stations is only 0.7° F. at the 5-foot elevation, and 1.6° F. at the 10-inch elevation. Comparing these differences with the average differences between the two stations before the cover crop was removed from the north plot, it will be seen that the removal of the cover crop had practically no influence on the minimum temperature at the 5-foot elevation. At the 10-inch elevation there was a difference of 1.0° F. due to the removal of the cover crop.

These data indicate that under the conditions which prevailed during the period covered by these observations, the cover crop had practically no effect on the minimum air temperature during the night at a height of a few feet above the ground. The depression of temperature of 1.0° F. at 10 inches above the ground, which can be attributed to the influence of the cover crop, would not have much bearing on the amount of damage to fruit, since there is little fruit within that distance from the ground.

In order to note the influence of the cover crop on the rate of fall in temperature at night and the rate of rise in temperature in the morning, semihourly temperatures for 24-hour periods during each of the 16 days on which frosts occurred after the cover crop was removed from the north plot were averaged and plotted. To show what was the normal relation between the daily march in temperature at the two stations, semihourly temperatures for the cold nights before the cover crop was removed were also averaged and plotted. As 29-hour thermographs were used, and the records were checked frequently on cold nights, both as to time and temperature, it was possible to calculate these semihourly temperatures to tenths of a degree with considerable accuracy.

The average semihourly temperatures for the 5-foot shelters at both north and south stations during the period while the entire orchard was still in cover crop are shown in Figure 3. The same data for the period after the cover crop had been removed from the north plot are shown in Figure 4. These diagrams show that the only effect of the cover crop was to retard the rise in temperature in the morning about 15 minutes. At times during the rapid rise in temperature in the morning, the temperature was 2.5° F. higher in the clean cultivated plot than over the cover crop.

The effect of the cover crop was considerably greater at the shelter on the ground. A comparison of Figures 5 and 6, which show the difference in temperature at this elevation (10 inches above the ground) before and after the cover crop was removed from the north plot, brings out this point. The cover crop caused the temperature to fall more rapidly during the evening, and to rise more

FIG. 1.—View of instrument shelter on ground in south plot, showing height of barley cover crop, February, 1922.

FIG. 2.—Unsheltered minimum thermometers in south plot. Lower thermometer is 7 inches above ground and upper thermometer 24 inches above ground.

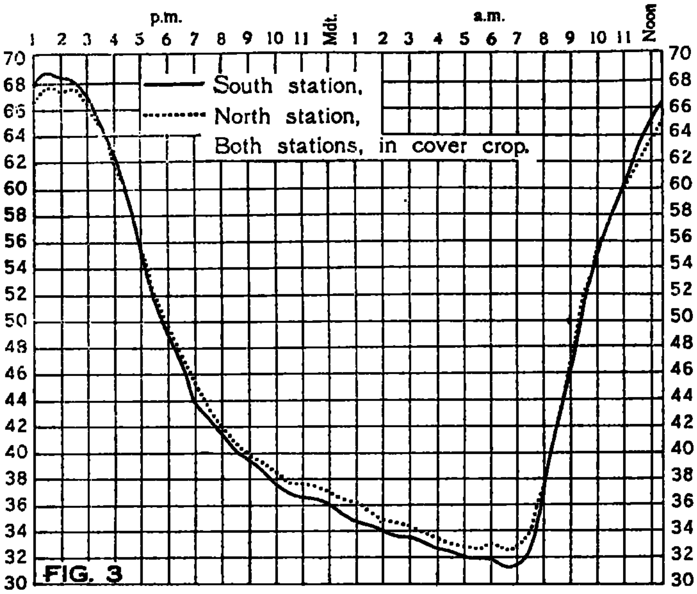

FIG. 3

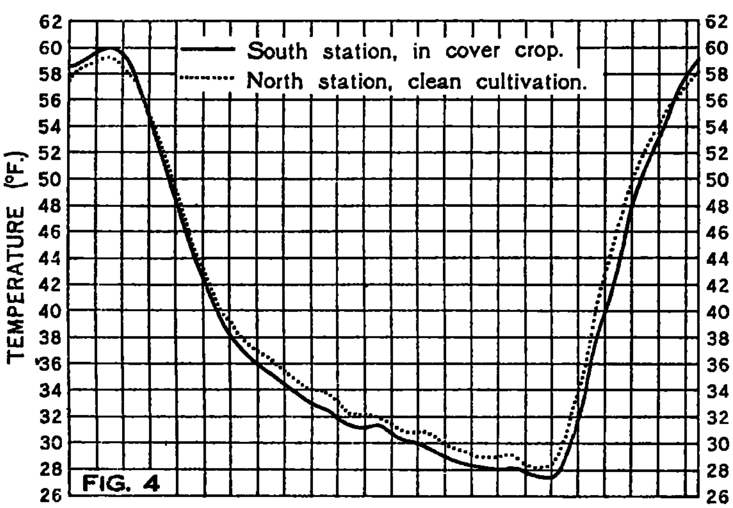

FIG. 4

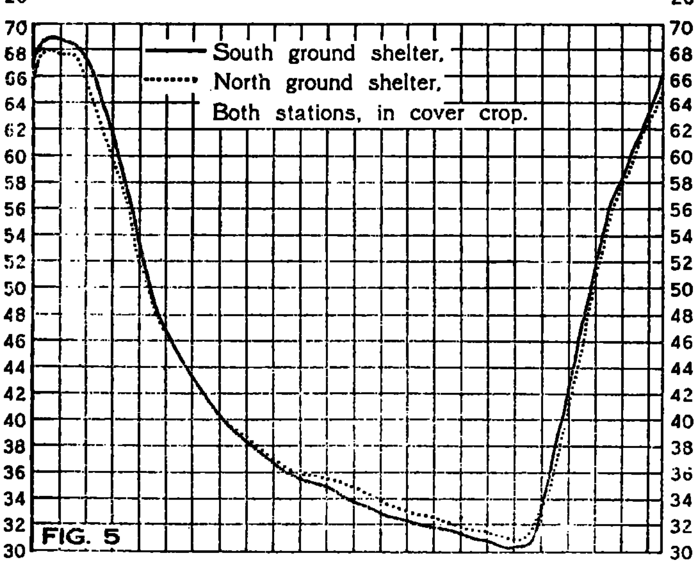

FIG. 5

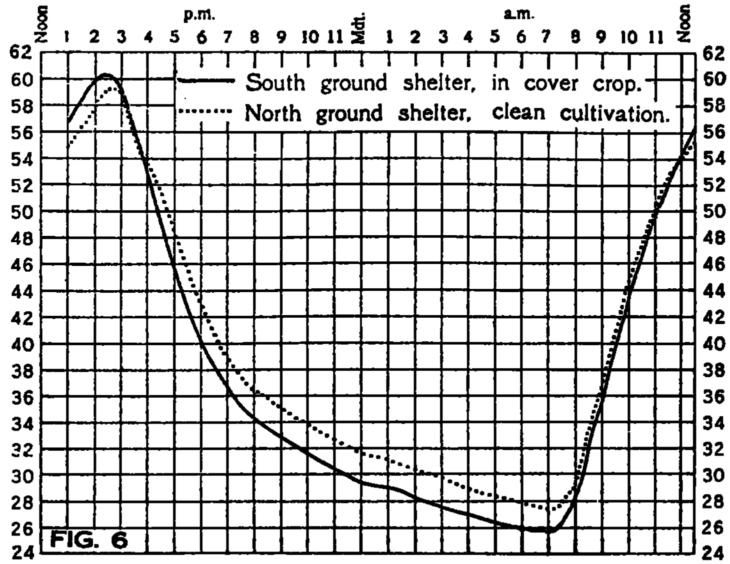

FIG. 6

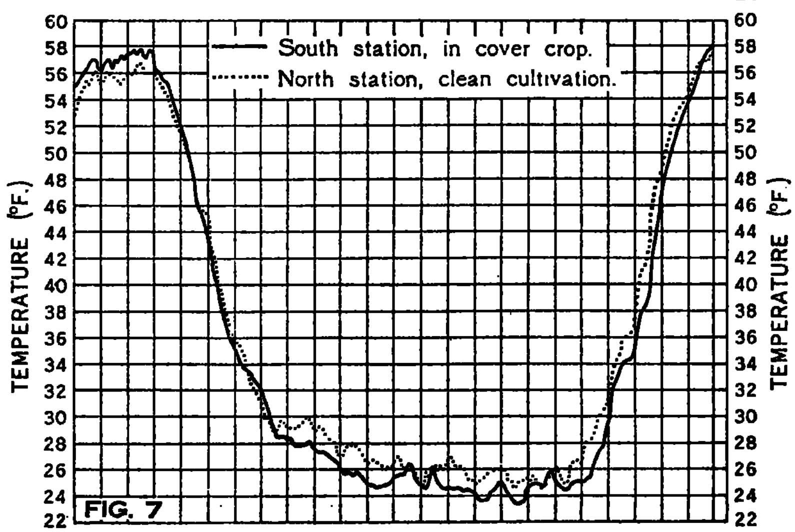

FIG. 7

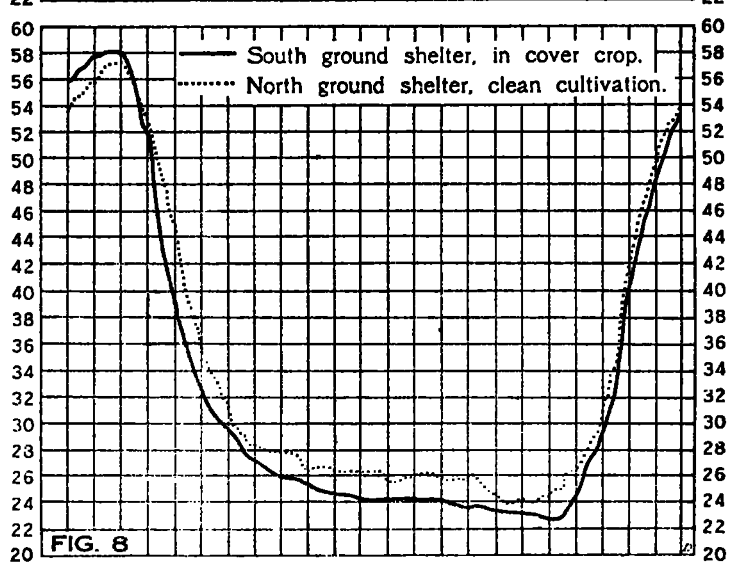

FIG. 8

slowly in the morning. During the early evening the difference in temperature between the two stations was about 2.5° F., and during most of the remainder of the night the cover crop area was about 2° colder than the clean cultivated area.

In Figure 7 are shown corrected thermograms, on a large scale, for the north and south 5-foot stations for the night of January 21–22, 1922, after the cover crop had been removed from the north plot. There was less air movement in general on this night than during any other night of the season. A comparison of Figure 7 with Figure 3 shows the effect of the cover crop on the temperature.

Figure 8 shows corrected thermograms for January 21–22, 1922, at the ground shelters at the north and south stations. It should be compared with Figure 5. Note the greater variations in temperature in Figure 7 as compared with Figure 8, due to the fact that the slight currents of air at the 5-foot elevation caused a mixing of the air strata of different temperatures, which was not felt at the ground.

A comparison of Figures 4 and 6 shows that with the exception of the time when the temperature was rising rapidly in the morning, there was little difference between the temperature at the 5-foot shelter and at the ground shelter, in the clean cultivated plot. In the south plot, on the other hand, over the cover crop, the temperature fell much earlier and more rapidly in the afternoon and evening and began to rise considerably later in the morning, at the ground shelter than at the 5-foot shelter. Over the bare soil there was little inversion at any time of the night.

OBSERVATIONS WITH UNSHELTERED THERMOMETERS.

It is well known that readings of unsheltered thermometers are affected by radiation of heat to the sky and deposit of dew or frost on the thermometers, so that they usually do not represent the temperature of the air. However, fruit growers often point out that a large portion of the tree and much of the fruit is exposed to the sky and that the temperatures which they assume on clear, calm nights are radiation temperatures rather than air temperatures.

Although the difficulty in analyzing data obtained with unsheltered thermometers was recognized, unsheltered minimum thermometers were exposed on posts at heights of 7 and 24 inches, respectively, at both the north and the south stations in the experimental grove. (See fig. 2.)

The lowest temperatures registered by these thermometers during 6 clear frosty nights before the north plot was plowed and during 14 clear frosty nights afterwards are shown in Table 3. The average difference in minimum temperature between the stations during the period before the north plot was plowed was 1.1° F. at the 24-inch elevation and 0.6° F. at the 7-inch elevation.

TABLE 3.—*Minimum temperatures, ° F., on frosty nights (unsheltered thermometers).*

[Entire grove still in cover crop.]

Date.	24-inch elevation.			7-inch elevation.			Condition of cover crop at noon.
	North plot.	South plot.	Difference.	North plot.	South plot.	Difference.	
Jan. 11...	33.0	31.4	−1.6	31.1	29.9	−1.2	Quite wet.
12...	29.1	29.0	−0.1	27.5	27.1	−0.4	Do.
13...	27.0	25.8	−1.2	25.0	24.4	−0.6	Slightly wet.
14...	28.9	27.9	−1.0	26.6	26.0	−0.6	Do.
15...	29.6	28.0	−1.6	28.4	27.8	−0.6	Quite wet.
16...	29.0	27.7	−1.3	28.0	27.4	−0.6	Very wet.
Average..	29.4	28.3	−1.1	27.8	27.1	−0.7	

TABLE 3.—*Minimum temperatures, ° F., on frosty nights (unsheltered thermometers)*—Continued.

[North plot clean cultivation; south plot in cover crop.]

Date.	24-inch elevation.			7-inch elevation.			Condition of cover crop at noon.
	North plot.	South plot.	Difference.	North plot.	South plot.	Difference.	
Jan. 20...	18.1	17.2	−0.9	18.2	16.7	−1.5	Heavy deposit of frost on cover crop in shade. South plot soil frozen solidly. Soil unfrozen in north plot, but trace of frost in shade.
21...	20.4	18.9	−1.5	20.4	17.7	−2.7	Frost on vegetation in shade: soil muddy in sun, with frozen soil underneath; frozen solidly in shade.
22...	23.0	21.0	−2.0	24.0	19.6	−4.4	South plot—Frost on vegetation in shade: ground frozen solidly in shade; soft mud on surface; frozen underneath in sun. North plot—No frost; soil dry at surface; wet underneath; unfrozen.
23...	23.2	21.5	−1.7	23.3	20.0	−3.3	South plot—Same as 22d. North plot—No frost; soil frozen beneath surface.
24...	25.9	23.5	−2.4	25.4	21.1	−4.3	South plot—Soil frozen in shade; unfrozen, damp, but not muddy in sun. North plot—Soil unfrozen; dry at surface.
25...	28.0	26.0	−2.0	27.7	23.1	−4.6	South plot—Ground frozen hard: frost on vegetation in shade. North plot — Ground unfrozen; no frost on ground.
26...	27.0	25.4	−1.6	26.9	24.0	−2.9	Vegetation dry; ground unfrozen.
27...	27.0	26.2	−0.8	27.0	24.6	−2.4	Same as 26th.
Feb. 1....	27.7	26.0	−1.7	27.8	25.0	−2.8	Soil and vegetation very wet.
2....	27.1	25.5	−1.6	27.1	24.4	−2.7	Vegetation dry; soil damp.
3....	24.1	22.9	−1.2	24.6	21.3	−3.3	Vegetation only slightly damp, but ground in south plot very muddy.
4....	26.0	24.5	−1.5	26.1	23.4	−2.7	South plot — Ground frozen, except surface, which is wet and muddy. North plot—Soil unfrozen, but very wet.
5....	27.4	26.0	−1.4	27.6	24.8	−2.8	Vegetation dry: ground damp.
6....	30.9	29.7	−1.2	30.8	27.9	−2.9	Vegetation dry; ground drying rapidly
Average..	25.4	23.9	−1.5	25.5	22.4	−3.1	

After the cover plot in the north plot had been plowed under, the differences in minimum temperature averaged 1.5° F. at the 24-inch elevation and 3.1° F at the 7-inch elevation. The depression of the minimum temperature due to the presence of the cover crop, as shown by these unsheltered thermometers, was 0.4° F. at the 24-inch elevation and 2.4° F. at the 7-inch elevation.

On cold nights the 7-inch thermometer in the cover crop plot was often heavily coated with ice and frost, at the same time the thermometer at the same elevation in the clean cultivated plot was absolutely dry. Also, the 7-inch thermometer in the cover crop plot was sometimes heavily coated with dew or frost, when the 24-inch thermometer, directly above, was perfectly dry. Undoubtedly, this deposit of moisture on the thermometers in the cover crop area was responsible in part for the difference in the temperature between the north and south plots after the cover crop had been removed from the north plot.

During the period when the temperature was falling rapidly in the evening the unsheltered thermometers showed exceptionally large differences in temperature between the cover crop area and the clean cultivated area. This was particularly true of the thermometer at the 7-inch elevation.

Current temperature readings taken during clear nights after the north plot had been plowed are shown in Table 4. It will be noted that temperature differences of as much as 11.0° F. were observed at the 7-inch elevation and 8.7° F. at the 24-inch elevation. These large differences were only temporary, however, and were due in part to differences in the effect of temporary breezes over the bare ground and over the cover drop. Over the bare ground the mixing of air strata of different temperatures caused the temperature down to the ground surface to rise, while the cover crop interfered with this mixing to such an extent that the effect of such winds was much reduced. The exceptionally large differences in temperature were never noted after the rapid fall in temperature in the early part of the night had ceased.

TABLE 4.—*Current temperatures, °F. (unsheltered thermometers).*

[North plot clean cultivation; south plot in cover crop.]

Date.	Time.	24-inch elevation.			7-inch elevation.			Notes.
		North plot.	South plot.	Difference.	North plot.	South plot.	Difference.	
Jan. 19	9:00 p. m.	23.2	22.3	−0.9	23.4	21.1	−2.3	Frost on cover crop; soil frozen in south plot; not frozen in north plot.
	10:50 p. m.	23.6	21.1	−2.5	23.4	19.6	−3.8	South plot 7-inch thermometer frost covered; others dry; crust of frozen soil just beginning to form in north plot; dead calm.
20	1:00 a. m.	20.0	18.8	−1.2	20.0	18.0	−2.0	
	2:45 a. m.	21.0	18.6	−2.4	21.0	17.9	−3.1	South plot 7-inch thermometer heavily frost coated; others perfectly dry.
	3:30 a. m.	19.5	18.7	−0.8	19.7	17.8	−1.9	Ground frozen in both north and south plots, but much more solidly in south than in north plot.
	4:00 p. m.	43.9	43.8	−0.1	42.7	39.9	−2.8	
	9:05 p. m.	23.1	21.9	−1.2	23.3	21.0	−2.3	South plot 7-inch thermometer frost covered; others perfectly dry.
	10:50 p. m.	22.0	20.6	−1.4	22.1	20.0	−2.1	
21	3:55 a. m.	22.0	21.0	−1.0	21.8	19.0	−2.8	Cloudless; dead calm.
	9:45 p. m.	25.3	24.7	−0.6	25.3	22.4	−2.9	Cover crop stiff with frost; south plot 7-inch thermometer heavily frost coated; others dry; no trace of frost in north plot.
22	3:50 a. m.	24.0	23.6	−0.4	24.0	20.9	−3.1	
	4:15 p. m.	51.3	49.0	−2.3	49.1	42.0	−7.1	
	8:45 p. m.	35.5	34.0	−1.5	35.0	30.2	−4.8	South plot 7-inch thermometer coated with frost; others perfectly dry. Strong wind blowing temporarily.
	9:30 p. m.	31.1	28.8	−2.3	30.6	26.3	−4.3	
23	4:15 p. m.	60.0	56.2	−3.8	59.0	48.7	−10.3	
	9.15 p. m.	31.6	28.9	−2.7	31.3	26.0	−5.3	Light northerly breeze; cloudless; no frost on any thermometer.
24	4:05 p. m.	62.5	60.1	−2.4	61.9	55.2	−6.7	
	9:45 p. m.	41.9	33.2	−8.7	41.0	30.0	−11.0	Liquid dew on south plot 7-inch thermometer; others perfectly dry.
	11:00 p. m.	32.9	30.2	−2.7	32.1	28.0	−4.1	
25	6:45 p. m.	44.1	40.0	−4.1	43.7	36.3	−7.4	Calm; dew covers south plot 7-inch thermometer; others perfectly dry.
26	4:15 p. m.	65.5	63.6	−1.9	64.8	58.0	−6.8	Calm; surface soil dry in north plot; quite damp in south plot.
	6:00 p. m.	48.4	44.6	−3.8	47.0	38.5	−8.5	Calm; vegetation, and all thermometers perfectly dry.
27	4:15 p. m.	52.0	51.7	−0.3	52.0	50.6	−1.4	0.6 strato-cumulus clouds; moderate wind blowing.
	6:00 p. m.	46.9	45.1	−1.8	46.8	43.9	−2.9	Overcast with heavy, black stratus clouds; a little wind.
28	4:15 p. m.	47.6	46.6	−1.0	47.4	45.0	−2.4	Strong northwest wind; some clouds in sky.
	10:20 p. m.	27.6	27.1	−0.5	27.5	26.1	−1.4	Calm; cloudless; unfrozen dew on all exposed thermometers; both dew and frost on cover crop; frost on south plot instrument shelter.
Feb. 2	4:20 p. m.	48.4	48.5	+0.1	48.0	46.5	−1.5	
	7:45 p. m.	31.6	30.0	−1.6	31.5	28.0	−3.5	Calm; both north plot thermometers dry; dew on south plot thermometers.
	9:45 p. m.	29.5	27.9	−1.6	29.4	26.8	−2.6	North plot—Both thermometers perfectly dry; ground freezing. South plot—Bulb of 7-inch thermometer ice coated, with heavy frost-on scale; unfrozen mist on 24-inch thermometer; calm; ground frozen.
3	3:15 a. m.	26.3	26.0	−0.3	26.7	24.3	−2.4	Cloudless; calm; north plot thermometers perfectly dry; both 7-inch and 24-inch thermometers in south plot coated with frost; vegetation stiff with frost; ground frozen hard in both plots.
	3:45 a. m.	26.2	23.9	−2.3	26.4	22.4	−4.0	
	4:10 p. m.	48.8	48.1	−0.7	47.7	42.7	−5.0	
	9:20 p. m.	29.5	28.8	−0.7	30.0	27.8	−2.2	North plot—Heavy liquid fog on both thermometers. South plot—Ice on lower thermometer; unfrozen mist on 24-inch thermometer; calm.
	9:40 p. m.	29.0	28.0	−1.0	29.1	26.6	−2.5	
4	3:45 a. m.	27.0	26.0	−1.0	27.5	25.0	−2.5	North plot—Frozen dew on both thermometers. South plot—Both thermometers heavily coated with frost. Cloudless; dead calm; heavy frost on vegetation; ground frozen hard in both plots.
	4:15 a. m.	26.3	25.0	−1.3	26.7	23.8	−2.9	Cloudless; calm; north-plot thermometers perfectly dry; both 7-inch and 24-inch thermometers in south plot coated with frost; vegetation stiff with frost; ground frozen hard in both plots.

There is a strong probability that the large differences in temperature between clean cultivated citrus groves and those in cover crop, reported by some growers, were temporary differences shown by unsheltered thermometers.

In so far as the formation of dew, ice, or frost affected the temperatures registered by the unsheltered thermometers in the cover crop area, the depression of temperature from this did not apply to the greater portion of the trees, since the deposit of moisture or frost was usually confined to the thermometer 7 inches above the ground. As a general rule the thermometer at the 24-inch elevation was dry. The notes in Table 4 bring out this point.

CONCLUSIONS.

The orchard used for these experiments was too small to indicate definitely what effect a cover crop covering a large area would have on the temperature. At the same time, it is not likely that the temperature at a height of several feet above the ground over a large area in cover crop would be affected to a much greater extent than the temperature at a height of a few inches above the ground over a small area. The cover crop in the experimental grove was exceptionally heavy; much heavier than any other winter cover crop that has come under the observation of the writer in southern California.

It should be mentioned here that during the entire period covered by the cover crop experiment the ground was very damp and often was wet and muddy. It is possible that greater differences might have been found if the surface soil had been dry or only slightly damp.

The orange crop on the trees was a total loss in both the clean cultivated and cover cropped portions of the grove. There was some slight foliage injury as well.

For six days and nights during the cold period in January the ground was frozen solidly to a depth of nearly an inch in the cover cropped portion of the grove. During this time the ground in the clean cultivated portion was frozen at night, but thawed out early in the morning. Toward the end of the extremely cold period, the soil in the clean cultivated area was sufficiently dry to prevent freezing at the surface. It is suggested that

this freezing of the surface soil, especially where continuing over so long a period as noted above, may injure the hair roots near the surface of the ground and thus weaken the tree.

TABLE 5.—*Effect of cover crop on amount of temperature, °F., inversion near ground.*

[Average minimum temperature on clear nights.]

SHELTERED THERMOMETERS.

	North plot.			South plot.		
	5-foot elevation.	10-inch elevation.	Difference.	5-foot elevation.	10-inch elevation.	Difference.
Both plots in cover crop	31.5	30.7	−0.8	30.9	30.1	−0.8
North plot in cover crop; south plot clean cultivation	26.9	27.0	+0.1	26.2	25.4	−0.8

UNSHELTERED THERMOMETERS.

	North plot.			South plot.		
	24-inch elevation.	7-inch elevation.	Difference.	24-inch elevation.	10-inch elevation.	Difference.
Both plots in cover crop	29.4	27.8	−1.6	28.3	27.1	−1.2
North plot in cover crop; south plot clean cultivation	25.4	25.5	+0.1	23.9	22.4	−1.5

The unsheltered thermometers show this in a somewhat greater degree. (See Tables 4 and 5.)

The bare soil probably was warmed up to a depth of 2 or 3 inches during the day, and this heat was conducted to the surface during the night, partially maintaining the temperature of the surface layer of air. On the other hand, the cover crop shaded the soil, preventing its warming up to any considerable extent during the day and also acted as an insulating agent between the surface of the soil and the surface layer of the air during the night.

It is not possible to draw a definite conclusion from observations covering only one frost season, but all the evidence obtained thus far indicates that a cover crop has little effect on the temperature a few feet above the ground. If this conclusion is borne out by experiments, which it is hoped to carry out in later seasons, any increased damage to fruit by frost in a cover-cropped citrus grove must be attributed to some other agency than a depression of the air temperature by the cover crop. If the greater damage found in cover-cropped groves can not be explained by natural differences in temperature, due to difference in elevation or other such cause, the answer may be found in a physiological effect of the cover crop on the tree.

One of the principal effects of the cover crop on the temperature is due to its shading the ground and thus preventing the warming of the soil during the day. This effect is discounted, however, in a citrus grove of old trees, because the trees themselves shade a large proportion of the ground and prevent the sun's rays from warming the soil to the extent that would be the case if there were no trees present. It readily can be seen that the effect of a cover crop in depressing the temperature on a clear, calm night would be greater in a grove of young trees, and still greater in an alfalfa field, without trees.

An interesting point brought out in this work was the fact that there was no temperature inversion within 5 feet of the ground over the clean cultivated area. There was a difference of nearly a degree between the 5-foot shelter and the ground shelter while the cover crop remained, but this difference disappeared entirely when the cover crop was removed. This is brought out in Table 5.

A SECOND EXPERIMENT ON COVER CROPS.

A second experiment with the object of determining the influence of a cover crop on the frost hazard was carries on by Mr. Eckley S. Ellison, observer, U. S. Weather Bureau, on the property of the Fontana Farms Co., near Fontana, Calif. That settlement is situated in extreme southern San Bernardino County about 45 miles due east of the town of San Bernardino.

Mr. Ellison's observations were made at the 5-foot level above the ground on a clean cultivated area and on one that was covered with grass and clover. A portion of the experimental plot was plowed under and the observations continued. His conclusions as given in his own words follow:

> Results obtained in this experiment tend to show that a cover crop increases the frost hazard, although the amount of the increase is so small as to be practically negligible. At a distance of 5 feet above the ground, the lowering of temperature amounts to less than half a degree F. Also the duration of critical temperatures is not affected to any practical extent regardless of the condition of the surface, whether cropped or clean.
>
> It might be that when large areas are planted to cover crops the influence on the temperature would be more marked, but it is the writer's belief that even then no considerable influence would result, due to the relatively small effect detected when a plot of 5 acres is used as a basis of comparison.
>
> Since the effect of a cover crop, although small, can be noted at an elevation of 5 feet, there is reason to suppose that from that height down to the surface of the ground a greater influence would be exerted. The results of this experiment can not, therefore, be construed to fit the case of a grower who has a considerable portion of his crop below the 5-foot level. Within the cover crop itself the influence of the vegetation is probably great—two or three degrees at least * * *.

—*A. J. H.*

CALCULATING TEMPERATURE EXTREMES IN SPOKANE COUNTY, WASH.

By E. M. KEYSER, Meteorologist.

[Weather Bureau, Spokane, Wash., October 19, 1920.]

Whatever degree of success was attained in temperature calculations in Spokane County last spring came as a by-product of the survey work authorized here by the Chief of Bureau. The original stimulus for undertaking these calculations came from a personal knowledge of the work being done in southern Oregon and California by Meteorologist Floyd D. Young. This stimulus was intensified by the various inspirational and very practical articles in MONTHLY WEATHER REVIEW SUPPLEMENT No. 16 (Predicting Minimum Temperatures From Hygrometric Data). The scope was greatly augmented by the willing and accurate clerical work done by Observer Frank B. Whitney, specially assigned to aid in the survey.

SCOPE OF 1922 TEMPERATURE SURVEY.

Spokane County, 54 miles long and 36 miles broad, touching Idaho on the east, reaches within 66 miles of the Canadian border. In the survey lasting from April 9 to June 13 temperature records were obtained from nine stations outside of Spokane, which is near the center of the county. Five of these were in Spokane Valley east of